# Power Efficient Distant Controlled Smart Irrigation System for AMAN and BORO Rice

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***Abstract*— Irrigation is the process of applying appropriate amount of water to crop fields at needed interim. Irrigation is an exigent part of cultivation of rice. Although, the overall yield of rice paddy predominantly depends on proper irrigation, irrigation process in developing countries like Bangladesh is still backdated. This study proposes an Arduino/GSM based remotely controlled power efficient smart irrigation system for crops that need to be immersed in water during its growing period. It will ensure the proper irrigation of a field by monitoring water level of the paddy field, providing feedback to farmers and giving farmers option to control the water motor via SMS. This study is expected to improve the overall production of AMAN and BORO rice of Barishal region by automating the traditional irrigation system. Also it will provide a more sophisticated irrigation system for similar types of crops.**

***Keywords*—Automation, Irrigation, AMAN rice, Arduino, GSM module, GSM/GPRS, SMS, BORO rice, AWD**

## I. Introduction

Rice is basically the seed of a grass species whose scientific name is *Oryza sativa*. Rice constitutes the dominate portion of diet for a large portion of world's human population, especially in Asia [1]. Bangladesh is world's fourth largest rice producing country, yielding total of 34.18 million metric tons. Cultivating rice three times a year, the average production of rice in our country is 4.2 metric tons per hector [2]. On the other hand, the average production of rice in Japan and China is 6-6.5 metric tons/hector, while they cultivate only once a year [2]. The major difference among those countries and Bangladesh is that they use modern technology in their cultivation, in every aspect possible, from sawing seeds to irrigation to collect crops. Whereas, we still use traditional methods for cultivating crops. The proposed system is expected to result a significant advancement in the process of automation of irrigation system in Bangladesh.

In Bangladesh total land area is 14.8 million hectares of which about 7.8(59%) million hectares land are cultivable and 25% is unavailable for cultivation [3]. As the population is increasing, unplanned urbanization, industrial plants, roads are reducing available lands for cultivation. Though Bangladesh has a large amount of natural water source and many corps are irrigated naturally by rain, about 46% of the cultivable lands need to be artificially irrigated. 80% of these lands are used for rice cultivation which need much more water than any other crops [4]. If proper irrigation is not insured for rice cultivation, the formation of rice plants is hampered even crops can be spoiled. In this situation from the limited lands, water and energy supplies, increasing the production of rice is a must.

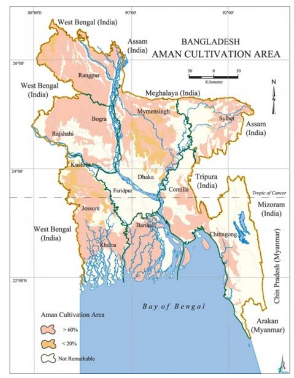



Fig. 1. AMAN cultivable area over Bangladesh. [5]

Fig. 2. AMAN seed planting. [7]

In Bangladesh different types of rice such as AUSH, AMAN and BORO are cultivated throughout the year. Among them, AMAN rice is most important and occupies about 60% of cultivable land and 46% of total crops [6]. Fig. 1 shows the areas of Bangladesh where AMAN is cultivated. Typically the seed of AMAN rice is planted on the field in the month of July to September and harvested within the end of October to start of November. Fig. 2 shows the planting of AMAN seeds. Now-a-days about 58% of total cultivable lands use some form of irrigation system. But in the case of AMAN rice cultivation, only 11% of the cultivable land is under irrigation and as a result, the AMAN rice cultivation depends on rain [6]. Average rain in Bangladesh is 2100 mm but there is significant deviation from the average rate of rain in different areas each year [6]. Even in some areas there is no rain at the season of AMAN cultivation. If there is less rain or no rain at all during the end of September, AMAN cultivation is severely damaged due to drought. Therefore, it is important to insure a proper irrigation system to maintain the water level during AMAN cultivation as AMAN rice contributes mostly in overall cultivated rice in Bangladesh. A proper irrigation can increase AMAN rice cultivation up to 60% [6].

BORO is another season for cultivating rice in Bangladesh. Typically the seed of BORO is planted on the field in the month of November to February and harvested within the end of March to start of June. The average production of BORO is 6.1-6.4 metric ton per hector. The paddy filed in BORO season needs to be artificially irrigated, as natural water resources have less water reserved in this season [2]. For this reason, the production of BORO is much less in our country as farmers do not want to take the hazard of watering artificially all their lands. But, if the proposed system is applied, the difficulties caused by manual irrigation will be eradicated by automation and farmers will be inspired to cultivate rice at BORO season. As BORO has more rice production per hector, it will increase the overall rice production of our country.

The proposed system, namely Power efficient distant controlled smart irrigation system can be used as a great tool to improve present irrigation problems. Using this system water resources will be saved as water is being given according to needs. Electrical energy consumption will be reduced as the motor is not being turned on unnecessarily. Cultivable lands can be maintained more easily as farmers will be able to control and monitor more than one land using same system. There will be no need of excessive manual works for managing more than one piece of lands.

We demonstrated the efficiency of the system on BORO rice. The result of the study was significantly better then present irrigation system. Appropriate water level was always maintained using this device which is required for BORO cultivation. More rice was produced using less electrical power and wasting much less water resource.

This paper is organized as follows, Section II provides the Literature Survey, Section III describes the System Design, Section IV provides System Development, Section V gives the Result and Discussion and Section VI concludes the paper.

## II. LITERARY SURVEY

There have been several researches on making of an automated irrigation system. In this section some such researches are discussed in order to find out what influence they have on present circumstance of Bangladesh cultivation.

Ale et al. suggests a system [8] that uses temperature and soil moisture sensor to sense the current condition of soil. The soil moisture sensor senses the moisture of the land and the temperature sensor senses the current temperature of the soil. According to the current value of soils moisture and temperature, irrigation is controlled. The sensors pass the data to an Arduino board, which acts as the brain of the system. This board turns on or off the solenoid valve attached to it according to the values of sensors. Thus the moisture of the soil is confirmed.

Guru et al. suggested a system that use multi sensor to precept the current condition of soil [9]. Multi-sensor is a combination of temperature sensor, humidity sensor, motion sensor, light sensor, vibrating sensor and UV sensor. The multi sensor sends PH and moisture value to the Arduino. It then takes appropriate action to water the soil which includes turning on a water motor, switching solenoid valve. This system introduced a GSM and GPRS module that is used to send information to the farmer.

A compound system was proposed in [10]. The paper states there will be many sensors scattered in the field. Each sensor will be connected to an Arduino board. They will send sensor status to the central controller, a raspberry pi module. The raspberry pi board then controls the status of the motor and also sends information to the farmer about the state of the motor via internet.

Another concept makes use of microcontroller ATmega328 which gets moisture and temperature sensed by sensors and controls the pump driver [11]. For each crops, there will be a predefined level of moisture and temperature. If the moisturizer and temperature is deviated from predefined level, the Arduino will command the motor driver to turn on the motor. A servo motor is used to specify the angular position of the pipe to make the best use of water. LED indicator indicates the current state of the pump.

Angelopoulos et al. suggested a smart system for garden watering that used sensor motes that process gathered information and communicates them to other motes [12]. Soil humidity sensors sensed the condition of soil, mote driven electro-valves control the water flow towards the plants. Each motes are independent to each other. A java application collects data from sensors and stores them on MySOL database for further use.


Fig. 3. Water level indicating pipe (AWD).

An efficient water level indicating system was developed by BRRI known as AWD(Alternating Weighting and Drawing) [2].This system use a PVC pipe of 7-10 cm diameter and 25 cm of height. It has some holes in the 15cm lower part of its body. In its standard setup, its 15 cm lower region with holes implants under the soil and 10 cm upper region stands above the surface. The main purpose of the tube is to observe the water level. The tube allows detecting water availability in the field beneath the soil surface. After the irrigation in the crop field, the water level continuously decreases because of evapotranspiration, seepage, and percolation. Because of the installed tubes in the field, it is possible to observe the water level below the soil surface up to 15cm to 20 cm.

From the aforementioned discussion, it appears that, most of the researches deal with the soil moisture and temperature condition rather than the water level that is also a useful parameter of smart irrigation, especially for crops that needs to be immersed into water such as deep-water rice. It may therefore be advantageous to build a system that will be used for maintaining water level and also make the process of farming easier.

## III. System Design

In this Section, the overall system design is described. Fig. 4 shows the complete block diagram of the system. The components required for the system is described in the following subsections.

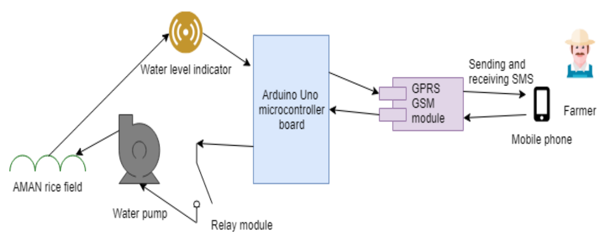
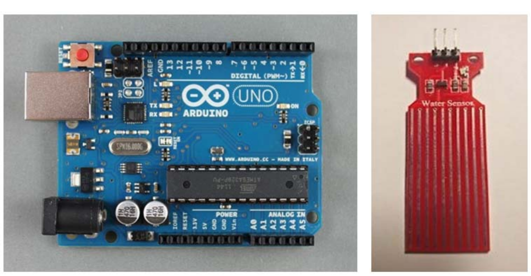



Fig. 4. Block diagram for energy efficient smart irrigation system.

### A. Arduino Uno Microcontroller Board

It is a microcontroller board powered by ATMEGA328 which has a 16 MHz crystal oscillator. It has 14 input/output pins, 6 of which can be used as Pulse Width Modulation (PWM) outputs. There are 6 analog input pins. The water level readings are read through one of these pins. Digital pins are connected to relay and GSM modules (Fig. 5 (a)).




(a) (b)

Fig. 5. (a) Arduino UNO and (b) Water level indicator

### B. Water Level Indicator

It is a cost effective water level sensor in which some parallel wires are kept exposed that can conducts electricity in presence of water, thus sensing the water level (Fig. 5 (b)).

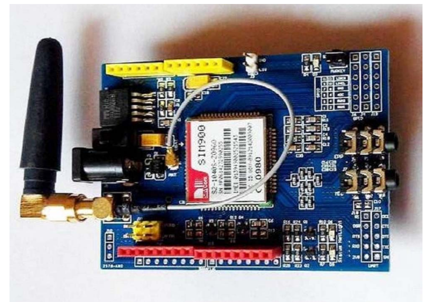


Fig. 6. GPRS GSM SIM900 Arduino module.

### C. SIM900 Module

This is a GSM/GPRS module which gives a way to send or receive voice calls and SMS to any number (Fig. 6). In this system this module is used to send and receive SMS stating on/off state of the water pump and water level information of the field.


Fig. 7. Relay module.

### D. Relay Module

This module is used to switch AC powered water pump as directly controlling higher voltages power device is not possible using given micro-controller (Fig. 7).

Fig. 8. Water pump

*E. Water Pump*

Water pump converts electrical energy to mechanical energy for Water lifting. Our system prototype uses a 0.5 HP water pump that draws 2.4 liters of water per second. (Fig. 8).

The flowchart for this system is depicted in Fig. 9. This flowchart shows all the action sequences of this system.

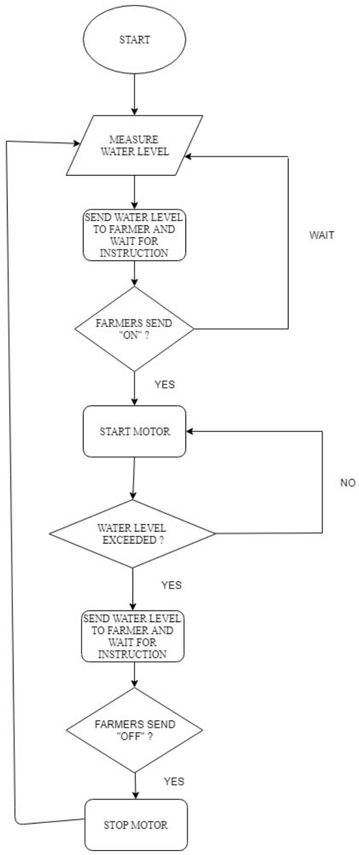



Fig. 9. System flowchart.

## IV. System Development

The main component of this system is Arduino Uno microcontroller board which controls the actions needed to ensure water level of the field. An electrical water level indicator is planted on the field inside the AWD pipe. This sensor continuously determines the water level of the field. The microcontroller analyzes the data given by the sensor and ensures the desired water level. If the water level is very low then the microcontroller signals the SIM900 module to send a SMS to farmers mobile phone indicating the low level of water. The farmer then sends a specific keyword to the SIM that is installed in SIM900 module. The SIM900 module then pass the signal to an Arduino board and the microcontroller then turns the 5V relay on which then turns the 220V line of the water pump on. Again, when water level is up to the mark, the microcontroller sends an SMS indicating the water level and waits for farmer's instruction. When the farmer sends a command to turn off the motor, Arduino board then turns off the relay thus turning off the water pump.

TABLE I
Energy Consumption Improvement Over Existing System

| **Growth stage** | **Energy consumption in KWh/kg for Existing system** [13] | **Energy Consumption in liter/kg using proposed system** | **Improvement(in percentage)** |
|---|---|---|---|
| **Nursery** | .0027 | .0020 | 25.92% |
| **Main field preparation** | .0137 | .0104 | 24.08% |
| **Planting to PI** | .0314 | .0258 | 17.83% |
| **PI to flowering** | .0286 | .0234 | 18.18% |
| **Flowering to maturity** | .0086 | .0065 | 24.42% |
| **Total** | .0850 | .0681 | 19.88% |

TABLE II
Water Consumption Improvement Over Existing System

| **Growth stage** | **Water requirement in liter/kg for Existing system** [13] | **Water requirement in liter/kg using proposed system** | **Improvement(in percentage)** |
|---|---|---|---|
| **Nursery** | 66 | 46.925 | 28.82% |
| **Main field preparation** | 330 | 250.625 | 23.82% |
| **Planting to PI** | 755 | 619.841 | 17.88% |
| **PI to flowering** | 687 | 562.268 | 18.18% |
| **Flowering to maturity** | 206 | 157.015 | 23.78% |
| **Total** | 2044 | 1636.675 | 19.91% |

## V. Result and Discussion

This smart irrigation system was deployed in a small test field of "BIRI 28" rice of BORO variety. The experiment was held in a sample field of 1 decimal under irrigation management division in Bangladesh Rice Research Institute of Barishal division. "BIRI 28" rice typically needs 1100 mm to 1300 mm of water. This level was ensured by this system. Table I and Table II shows the relative comparisons of energy and water consumption of existing and proposed system. Fig. 10 shows the improvements in graphical form. As can be seen from the table that the proposed system improves the energy consumption of "BIRI 28" rice by 19.88% and the water consumption by 19.91%.

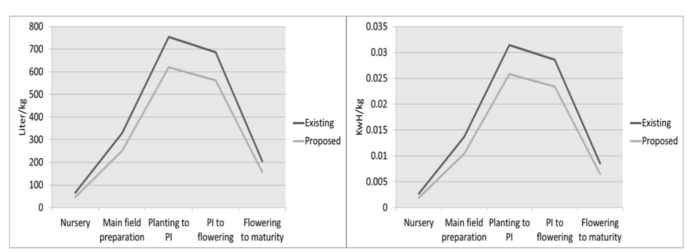



Fig. 10. Relative comparison of water and energy consumption

## VI. CONCLUSION

In this paper, a energy efficient smart irrigation system is proposed that is proven to give much better performance than existing system of irrigation. However, this system is suitable for crops that need to maintain certain level of water for growth. It can be upgraded to a point where it can control all types of irrigations including irrigation for those crops which need specific soil moisture. Adding weather prediction as a parameter can give us more efficient results as there are many crops which depends on weather forecast. Further work will address these issues.

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